EFFECT OF ROW SPACING ON YIELD AND YIELD COMPONENTS OF BREAD WHEAT (*Triticum aestivum L*) VARIETIES AT SHESHEMENE DISTRICT, WEST ARSI ZONE IN OROMIA REGIONAL STATE.

M.SC THESIS

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COMPONENTS OF BREAD WHEAT (*Triticum aestivum L*)

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I declare that this thesis is my real work and all sources of materials used for this thesis have been properly acknowledged. I seriously declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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DEDICATION

I dedicate this thesis manuscript to my beloved mother Safiya Guye for her support throughout my life and lost her before the end of this paper.

LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of variance
CSA	Central Statistical Agency
CV	Coefficient of variation
FAO	Food and Agricultural Organization of the United Nations
GY	Grain yield
HI	Harvest index
LSD	Least significance difference
NSPS	Number of seeds per spike
PH	Plant height
RCBD	Randomized complete block design
SAS	Statistical analysis system
SPL	Spike length
TBM	Total biomass
TSW	Thousand seed weight

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Effect of row spacing on yield and yield components of bread wheat (*Triticum aestivum* L) varieties in oromia, west arsi zone, sheshemene woreda.

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ABSTRACT

Wheat is among important cereal crops produced by many farmerrs in Ethiopia, having a great nutritional and economic importance. However its productivity has been constrained due to various biotic and abiotic factors. An experiment was conducted at Farmers' Training Centre of Sheshemene, West Arisi zone of Oromia Region in Ethiopia in 2021 main cropping season, to study the response of different wheat varieties to various row spacing. The experiment was laid out in RCBD design with Factorial Arrangement having four replications. Four varieties of Bread wheat (Shorma, Pavon 76, Ogolcho and King bird) and three row spacing (15, 25 and 35 cm) were studied during the course of study. The interaction effect of variety and row spacing were not significant in yield, plant height and harvesting index and characters studied. The effects of row spacing was not significant either on number of tillers, spike length and days to maturity. However, the effect of row spacing was significant (P<0.05) on harvest index, ,number of seeds per spike, thousand seed weight ,plant height, total biomass weight, days to heading and grain yield. For each trait the maximum value was obtained at row spacing of 15 cm. The effect of variety was significant on all parameters . Variety shorma had the maximum values in number of tillers(10.2), plant height (81.8 cm), total biomass weight (4.39g), grain yield (4405 kg/ha), spike length (7.32cm), number of seeds per spike (57.0kg), and thousand seed weight (37.5 gram). The use of Variety Shorma on spacings of 15cm can be recommended for production of bread wheat for the study area and other areas with similar agro ecologies.Based on reaserch finding15cm spacing gives highire yield with variety shorma .Therfore the effect of row spacin on yield and yield component of bread wheat varieties need father reaserch.

Key Words- Wheat-varieties, Row-spacing, Growth, Yield, Yield-components, parameter

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is most widely grown cereal crop in the world. It is also the world's leading cereal grains used by more than one-third of its population as a staple food (*Kumar et al., 2011*). Wheat plays an important role in everyday life of the world's population and provides over 21% of the food calories and 20% of the protein to more than 4.5 billion people, there by playing a fundamental role in food security (*Braun et al., 2010).* Wheat is used for food and many industrial purposes.

Ethiopia is the largest wheat producer in sub-Saharan Africa with a record harvest of 4.6 million metric tons registered in 2017 (CSA 2019). However, during that same year, the country imported 1.5 million tons of wheat, corresponding to a value of around $600 million (CSA 2019). Further increases in demand for wheat (and other cereals), due to population growth and dietary changes (*van Ittersum et al. 2016*), are projected to put additional pressure on the national treasury,making the national economy vulnerable to cereal price volatility in world markets. Wheat (*Triticum aestivum* L.) is an important staple food crop in Ethiopia, especially in urban areas. Wheat is also the fourth largest cereal crop produced by about 5 million smallholder farmers,that is, about 35% of all small farmers in the country. The global annual wheat production is 731.6 million metric tons from an area of 215.87 million hectares giving an average yield of 3.39 metric tons ha-1(USDA, 2019). In Ethiopia, it is one of the major staple and strategic food security crops with an average annual production and productivity of 4.64 million tones and 2.73 tons ha-1 respectively (CSA, 2018). Wheat has great nutritional value and contains starch (60-90%), protein (11-16.5%), fat (1.5-2%), inorganic ions (1.2-2%) and vitamins (*Ali et al., 2014*).

Bread wheat is known to be a major source of energy and protein. Traditionally the crop is used for making bread, porridge, Kinche and other types of foods like biscuit and pastry products.The straw is good source for animal feed and is also used for thatching roofs (*Mathewos et al., 2012*). Although wheat has a great nutritional and economic importance, its productivity has been constrained due to various biotic and abiotic factors (*Haidar et al., 2014).* In Ethiopia both bread and durum wheat are widely grown in the country constituting about 60% and 40% of the total wheat production, respectively (CIMMYT, 2014). Increasing wheat yield in Ethiopia, through narrowing yield gaps, is important to reduce the import dependency for this crop while avoiding area expansion. This needs to occur in a smallholder agriculture setting as wheat is cultivated by approximately 4.2 million smallholders on ca. 1.7 million ha (CSA 2019). Currently, wheat is produced mostly under rain fed conditions and with relatively low inputs (Anteneh and Asrat, 2020). The major wheat producing regions of the country are: Oromia, Amhara, Tigray and SNNPR regions (CSA, 2017) that share more than 83% of wheat production.

Despite the yield growth observed during the past 15 years (ca. 63 kg per hectar per year),with wheat yield doubling to values reaching ca. 2.7 t/ha (CSA, 2018), the current wheat yield is only ca. 20% of its water-limited potential (*Silva et al.2019a; van Ittersum et al. 2016).*Understanding and addressing the key drivers behind this large yield gap is thus important to help prioritize policies and interventions towards wheat self-sufficiency in Ethiopia.

Previous research concluded on wheat yield gaps in West Arsi, one of the wheat belts in Ethiopia, can be largely attributed to technology yield gaps (Silva *et al.* 2019a).

This means that technologies currently used by farmers do not reach agronomic best practices and that considerably more and better use of inputs is needed if wheat yield gaps are to be narrowed (*Habte et al. 2014*). Competition for labour during sowing, weeding, and harvesting is also observed in this administrative zone, as labour peaks for other cereal and legume crops overlap with labourpeaks for wheat. This results in potential tradeoffs on resource allocation at farm level and reflects the importance of contextualizing yield gaps within broad farming system aspects (Silva and Ramisch 2019b).

Oromia region accounts for the largest of all in the country with its top producing districts located in the Arsi-Bale areas of the region (*Warner et.al, 2015*).According to *Warner et.al, 2015,* East Shoa zone is also among the top 25 wheat producing zones in the country, major producing districts within the zone being Dugda and Gimbichu.

The total areas of wheat production in the Oromia Region in 2017 were reported as 898,455.57 ha with average yields of 2.97 t ha^{-1} (CSA, 2017). Wheat in district Sheshemene is the 3rd most important crop during main cropping season in terms of total production after tef and haricot bean with total land coverage of more than 8923 ha with average yields of 4 ton per ha (Sheshemene District Agricultural Office, 2020) which is below the regional average yield of {2.96} ton per ha (CSA, 2017).

Lack of agronomic practice such as disease resistant, high yielding and adoptable varieties, appropriate use of row spacing, lack of adequate improved seed and fertilizer application are common problems of the study area (sheshemene District

Agricultural offece,2021) Moreover, complete removal of crop residues from farm lands for fodder and fuel, low level of fertilizer application, limited use of manure, lack of appropriate soil conservation practices and cropping systems are among the main factors contributing to the decline in soil productivity *(Haileselassie et al., 2005).*

Row spacing determines resource availability and utilization by individual plants in a given species. Planting decisions require that optimum row widths for the seed crop be determined. If the row is too wide, the crop is unable to rapidly shade the inter-row area to capture sunlight and weeds quickly become established. If the row is too narrow, inter-row crop competition results in poorer yields, difficulties in disease and insect control, and greater likelihood of lodging. Moreover, choice of adapted high yielding varieties is one of the vital strategies to enhance wheat productivity, Determination of appropriate inter-row spacing and variety choice are dependent on weather and soil resources in addition to other socio-economic factors (Bezabih, 2020). Therefore, the purpose of this research was to evaluate the productivity of wheat varieties under different inter-row spacing, and to identify and recommend the optimum ones that would improve wheat productivity in the study area.

1.1. Objectives

General objective

To improve wheat production through employing appropriate agronomic management strategies in the study area

Specific objective

1. To study the effect of row spacing and varieties on yield and yield related traits of bread wheat

2. To determine optimum row spacing and identify high yielding wheat varietie for the study area

3. To identify the possible row spacing by variety interaction

2. LITERATUER REVIEW

2.1. Wheat (Triticum aestivum L.)

The domestication of wheat started about 10,000 years ago, as part of the Neolithic Revolution, through a transitional period when humans changed from hunting and gathering of food to settled agriculture (Shewry, 2009). Bread wheat is believed to have originated in South-western Asia where it has been grown for more than 9000 years (Zohary and Hopf, 2000). Center of origin is the Fertile Crescent region between the Tigris and Euphrates rivers (Sharma, 2012). Wheat spread into central Asia and Africa about 3000 years ago. It reached Africa initially through Egypt (Feldman, 2001). Today, wheat is widely grown in many parts of the world, across a wide range of environmental conditions, from sea level to over 3000 m.a.s.l. It is one of the main staple foods in both developed and developing countries for billions of people. Ethiopia is the first and largest wheat producer in sub-Saharan Africa (FAOSTAT, 2017).

2.1.1. Taxonomy

Wheat is an edible grain, one of the oldest and most important of the cereal crops. Wheat is a monocot member of the tribe *Triticeae,* family *Poaceae* and genus *Triticum*. Wheat is subdivided into a number of species that are classified according to the number of chromosome pairs they contain. The most common species of wheat grown are *Triticum aestivum* L. (bread wheat) and *Triticum turgidum var. durum* L. (durum wheat).

2.1.2. Importance

Wheat (*Triticum aestivum L.)* is one of the most important cereal crops in the global agricultural economy (Anon, 2006). World economy role of wheat production is significant in terms of cultivated land and food supply, feeding and commerce. Wheat is grown in more land area worldwide than any other crop and it is the third in total production after rice and corn in the world (Anonymous, 2015). Bread wheat is an important food security crop in Africa. There are about 4.6 million farm households who are directly dependent on wheat farming as a major source of food and cash in Ethiopia (*Bekele et al., 2014*). Wheat is highly nutritious, such that besides being rich in carbohydrates, it has protein content that exceeds all other cereal crops (*Singh et al., 2008*).

The greatest portion of the wheat flour produced is used for bread making. Wheat grain contains all essential nutrients; kernel contains about 12 percent water, including carbohydrates (60-80% mainly as starch), proteins (8-15%) containing adequate amounts of all essential amino acids (except lysine, tryptophan and methionine), fats (1.5-2%), minerals (1.5-2%), vitamins (such as B complex, vitamin E) and 2.2% crude fiber (Shewry, 2007). The straw is used as animal feed during the dry season and for thatching roofs.

2.2 Wheat Production in Ethiopia

Ethiopia is one of the largest wheat producers in terms of total wheat area cultivated and total production (CSA, 2012). In Ethiopia, wheat ranks fourth after teff, maize and sorghum in area coverage and third after maize and teff in total production (CSA, 2012; *Minot et al.,2015).* Within the country the top wheat producing districts are primarily located in Oromia, Amhara, and Tigray regional states. Oromia accounts for the largest of all with its top producing districts located in the Arsi-Bale areas of the region (*Warner et.al, 2015).* But, the production of wheat is tremendously of a subsistence nature and dominated by the country's numerous smallholder farmers that cultivate more of wheat for consumption and less of it for the market (*Matouš et al., 2013)*. Of course, as discussed by Minot et al. (2015) and CSA (2013), it is produced by both small-scale and large-scale commercial farms. However, according to Demeke and Marcantonio (2013), except some government-owned large-scale and commercial farms, wheat is produced predominantly by smallholder farmers under rain feed conditions. It is clear that in the country small-scale wheat farmers dominate large-scale commercial farms, and it has its own negative influence on production and productivity in the country and it affects the competitiveness of wheat quality at the world market**.**

The highlands of the central, south-eastern and northwest parts of the country are the main wheat-growing areas of Ethiopia. Regionally, the national production of wheat comes from Oromia (57.4%), Amhara (27%), SNNP (8.7%) and Tigray (6.2%) (CSA, 2014). Wheat has many uses like that of other cereal crops produced in the country. In Ethiopia, wheat grain is used in the preparation of different traditional as well as modern processed food products such as injera and other industrial processed products like pasta and macaroni (*Nigussie et al., 2015).* Besides, wheat straw is commonly used as a roof tacking material and as a feed for animals. So, wheat is an important cereal crop which should get emphasis on both its production and its marketing.

As we understand from the above-discussed information, wheat in Ethiopia is an important stable and cash crop in increasing income of the people, food security, employment and national GDP increment. However, its production and marketing is challenged by factors such as shortage of agricultural inputs, diseases and pests, shortage of infrastructures, shortage of institutional services, shortage of storage materials, product quality, low selling price and price cheating. But, in opposite to these challenges, available opportunities such as government policy, expansion of market, increasing demand for wheat and potential of the area for wheat production encourage wheat producers and traders to engage in wheat production and marketing activities.

Again with regard to the estimated yield, the report by CSA (2018) also mentioned that maize, teff and wheat within the category of cereals have shown increasing range from 7.32 to 28.93 quintals per hectare for maize; from 5.05 to 26.76 quintals per hectare for teff; and from 2.28 to 29.67 quintals per hectare for wheat over the last 5 years (2012/2013–2017/2018) post-harvest estimates. This indicates that wheat shows the highest increasing rate which is 22.39 quintals than teff (21.61 quintals) and maize (2.171 ton). Such increasing rate of wheat production is due to the implementation of several government programs and initiatives which drive agricultural growth and food security in the country (*Gebreselassie et al., 2017*). Report of FAOSTAT indicates that on average wheat production and total area coverage increased from 2000 to 2017.Specifically, there was an increasing rate of production and area coverage from 2000 to 2001, but it also shows a decreasing rate during 2002 and 2004.As indicated in production, productivity and area coverage vary between years. According to *Gebreselassie et al. (2017*), the main reason for this significant annual variation is primarily due to variation in rainfall which means that if the rainfall is good, the production is also good, whereas if the rainfall is not sufficient, the status of the production is also insufficient.

Despite good production and productivity trends made, Ethiopia has faced a growing supply deficit (*Bergh et al., 2012)*. Even if it shows increasing trend domestically, still Ethiopian wheat production is relatively small by global standards (*Hei et al.2017*).To increase the demand of wheat globally, the government should give attention through working together with large-scale commercial investors.

2.3 Effect of Raw Spacing on Growth, Yield and Yield Component of Wheat

Wheat production in Ethiopia faced immense production constraints that are affecting both its yield potential and industrial quality (*Amare et al., 2015*). Row spacing determines resource availability and utilization by individual plants in a given species. Planting decisions require that optimum row widths for the seed crop be determined. If the row is too wide, the crop is unable to rapidly shade the inter-row area to capture sunlight and weeds quickly become established. If the row is too narrow, inter-row crop competition results in poorer yields, difficulties in disease and insect control, and greater likelihood of lodging.

2.4. Effect of Seed Rate and raw Spacing on Growth, Yield and Yield Components of wheat

Proper row spacing and seed rate are most important management factor affecting the agronomic characteristics of wheat (*Ansari et al., 2006*, *Marwat et al., 2002, Chaudhary et al., 2000).* Late seeding dates normally result in higher seeding rates because a delay in sowing normally reduces individual plant growth and tiller production .Suitable combination of seed rate and row spacing could increase grain yield of wheat whereas seeding rates alone did not influence the grain yield. seed rate of 100-125 kg ha^{-1} with row spacing of 12.5 - 25 cm guaranteed maximum grain yield of wheat . They found that tillers were more in wider row spacing (37.5 cm) followed by 25 cm and 12.5 cm row spacing. *Chaudhary et al, (2000*) reported that seed rate of 150 kg ha^{-1} increased the number of grains spike^{-1} and depressed the number of fertile tillers m^{-2}. *Khan et al. (2001*) reported higher wheat yield at seed rate of 100-150 kg ha-1 in 27 cm- 13.5 cm a part rows, respectively. reported that row spacing of 20 cm resulted in significantly higher wheat grain yield in comparison with 30 cm row spacing; however, seed rate did not have effect on wheat yield.

After conducting field trials on two wheat cultivars concluded that grain and straw yields were high with 15 cm row spacing and decreased with increased row spacing while harvest index was not affected significantly by row spacing. *Arif et al. (2003)* suggested 150 kg ha-1 seed rate with 22.5 cm row spacing for maximum wheat yield. They also found that plant height, grains spike^{-1}, and 1000-grain weight decreased with increase in seed rate, however, tillering increased with increasing seed rate.

Research results reported by Anderson and Garlinge (2000) have shown that yields of wheat and barley increased as the spacing between rows is decreased similarly narrow row spacing consistently produced higher grain yield than wide row spacing (Chen and Neill., 2006. Johnson and Hargrove, 1988) whereas *Ahmad et al.* (2003) concluded that maximum grain yield and harvest index of wheat can be obtained with row spacing of 20 cm. Increasing seed rate of wheat from 100 to 200 kg ha^{-1} increased the grain and straw yields .

2.5. Effect of Seed Rate on Growth, Yield and Yield Components of Wheat

Seeding rate can impact on wheat tillering, grain yield and protein quality *Staggenborg et al.2003)*. Hence, achieving higher agronomic performance and better end-use quality requires optimizing and periodically reviewing management practices such as seeding rates. It was reported that, in a dense wheat population, grain yield was decreased due to competition between plants that induced self-regulation (*Jennifer et al., 2006).* However, in cultivars that produce fewer tillers, higher seeding rates compensated for reduced tiller and promoted more main stem spikes (*Staggenborg et al., 2003*)

Wheat quality was not reduced at higher seeding rates as protein content, kernel weight and test weight were unaffected (*Jennifer et al., 2006: Bryan, 2001)*. On the other hand, it was stated that protein concentration declined as seeding rates and yields increased (*Geleta et al., 2002*).The decrease in plant height in response to lowering the seeding rate to 100 kg ha^{-1} may reflect formation of more secondary tillers in less populated stands, which tend to be shorter in stature.

At the highest seeding density, the increased intra-plant competition may have also contributed to the reduction in plant height. *Chaudhary et al, (2000*) and *Arif et al, (2003)* reported that increased tillers with increase in seed rate. Who observed linear increase in the number of tillers as the seed rate was increased. Whereas, the findings are not in accordance with who found decreased tillers as the seed rate was increased. The results are in line with *Chaudhary et al, (2000*) who explained that lower seeding rates significantly increased the number of grains andvice versa. By increasing seed rate the number of grains spike^{-1} is reduced (*Khan et al, (2002*) and Mehrvar and Asadi, 2006).*Khan et al, (2002*) and Mehrvar and Asadi (2006)concluded that by increasing seed rate the 1000- grains weight is reduced.

These results are in analogy with the findings of earlier workers (*Arif et al., 2003; Khan et al., 2001*) Seeding rate can impact on wheat tillering, grain yield and protein quality (*Staggenborg et al., 2003)*. Hence, achieving higher agronomic performance and better end-use quality requires optimizing and periodically reviewing management practices such as seeding rates. It was reported that, in a dense wheat population, grain yield was decreased due to competition between plants that induced self-regulation (*Jennifer et al., 2006).*However, in cultivars that produce fewer tillers, higher seeding rates compensated for reduced tiller and promoted more main stem spikes (*Staggenborg et al., 2003*) Wheat quality was not reduced at higher seeding rates as protein content, kernel weight and test weight were unaffected (*Jennifer et al., 2006: Bryan, 2001*).

2.6 Influence of Variety hCoice on Wheat Yield Performance

Grain yields of wheat considerably increased during the 20th century and more than half of the global wheat production areas still witness yield increases (*Ray et al 2012, 2013, Iizumi et al 2014).* Major time periods of this increase are associated with the 'Green Revolution', with the beginning generally dated to the 1960s, and the corresponding development of genetically improved wheat varieties (*Evenson and Gollin 2003, Grassini et al 2013)* in combination with improved agronomic practices (Khush 2001, Fischer 2009). Known as ‘high yielding varieties, newer varieties are generally assumed to have a higher potential yield than those developed prior to the ‘Green Revolution’ (Evenson and Gollin 2003) with the potential yield defined as the expected yield in the absence of any biotic or abiotic stress using optimum agronomic management practices (Fischer 2015).

Several studies indicated that modern varieties out yield older varieties under both, poor and optimal environmental conditions, with modern varieties responding more strongly to environmental improvements and increased fertilizer supply Maggio 2006, De Vita et al 2010).More specifically, the superiority of modern wheat varieties was attributed to changes in plant physiological traits and processes, such as plant height, harvest index, biomass, 1000 kernels weight, root growth, water soluble carbohydrate content of stems and leaf sheaths, stomata conductance, growth rate, photosynthesis rate ,modified source-sink relations, water and nutrient use efficiency, and disease and stress resistance at the plant and/or at the canopy scale (reviewed in, e.g. Reynolds et al 2009). higher frequencies of drought, heat waves, or heavy rainfall events and face an increasing market volatility (Wiebe et al 2015, Macholdt and Honermeier 2017).

Thus, beside grain yield, yield stability is of high importance, and, to farmers, variety choice is considered the most important management tool (Macholdt and Honermeier 2017).

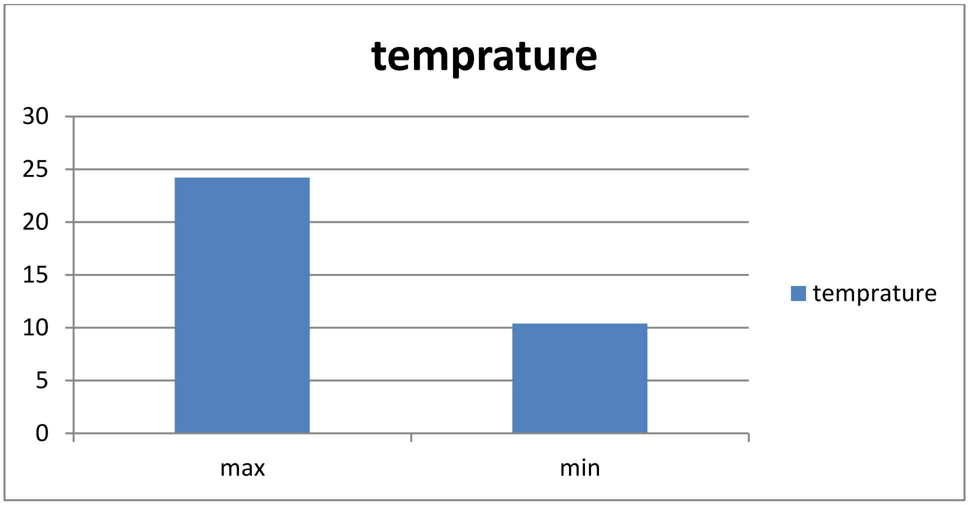
Most studies assessing the contribution of variety selection and breeding to changes in wheat grain yields are either based on unbalanced yield data obtained by testing varieties sequentially or on data originating from field trials with side-by-side cultivation of varieties released in different periods. Data derived from a side by- side cultivation of different varieties under pest- and disease-controlled conditions are less affected by changes in other factors, such as climate or agronomic management, and therefore assumed to be well suited for a realistic estimation of the genetic trend component. However, analyzing unbalanced yield data obtained at variety trials or using national yield statistics allows for considering a higher number of data sets and, thus, might be more representative for regional and national yield progress rates. Recent statistical methods, such as mixed effects models, allow for deriving the genetic gain even from unbalanced data sets with cultivation conditions strongly changing over time (*Smith et al 2005).*

3. MATERIALS AND METHODS

3.1 Description of the experimental site

The experiment was conducted under rain-fed condition during the main cropping season from the end of July to – December, 2021at Shashemene District, West Arsi Zone, of Oromia Regional stat,Ethiopian. The specified study area Bute Filcha kebele FTC(Farmer Training Center) is located at $7^{o}12'2''$ N and $38^{o}36'0''$ E having an altitude of 1964 meter above sea level (m.a.s.l.),. The mean annual rain fall is 983 mm and the average annual temperatures are min 10.4 ^{0}C and max 24.2 ° C.

	Months of the Cropping main season						
	JUN	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**Total**
Rain fall (mm) at KersaIlala	96.9	70.6	127.6	51.3	87	0.4	433.6
Rain fall (mm) at ChDNY	65.5	174.7	93.6	149.4	81	0	563.7
Min. Temp. (0C) at KersaIlala	10.3	11	10.3	9.6	11	7.2	Mean Ave. 10
Max. Temp. (0C) at KersaIlala	26.3	26.4	26.5	26.2	24	25	Mean Ave. 25.8
Min. Temp. (0C) at ChDNY	10.2	10.8	10	9.8	11	8.5	Mean Ave. 10.1
Max. Temp. (0C) at ChDNY	25.3	26.5	25.8	26.1	24	25	Mean Ave. 25.5


temprature
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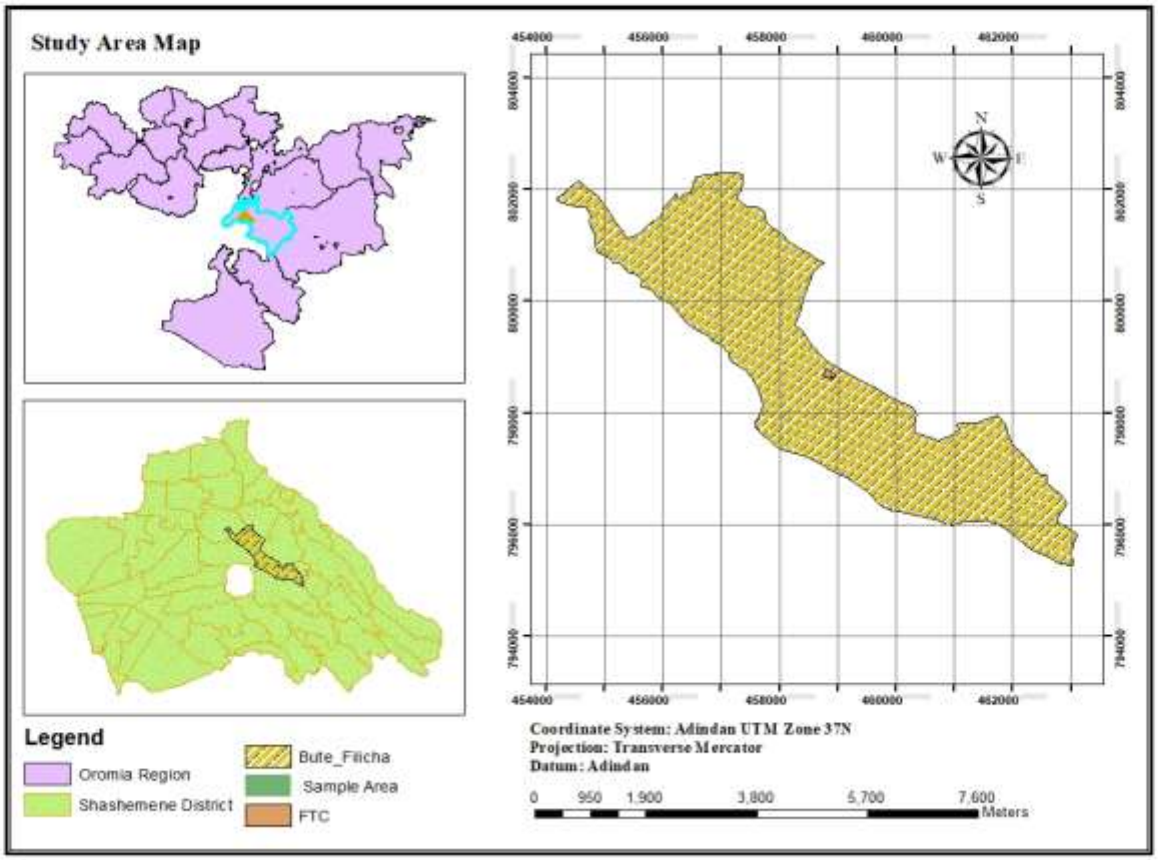

Fig.1 Map of Experimental site

3.1.1 Experimental materials

Four varieties involving king bird, Ogolcho, pavon 76 and Shorima were collected from Ethiopian seed enterprise of kofele branch and used to test different row spacings. Row Spacings were 15cm, 25cm, and 35cm. The seeds of the bread wheat varieties were collected from the past (2019/2020) cropping season harvest. The above varieties are currently under production in west Arise zone of Oromia.

3.1.2. Treatments and experimental design

The treatments made from a combination of four bread wheat varieties namely, king bird, Ogolcho (ETBW5520) pavon76 and Shorima and three row spacing's that included 15cm, 25cm and 35cm. The experiment was laid out in randomized complete block design (RCBD) in factorial arrangements with three replications. The size of each experimental plot was 2m long and 3m wide, accommodating 20 rows for 15 cm, 12 rows for 25 cm, and- ,9 rows for 35 cm. Each plot area is 6 m^2. Spacing of 1 m and 0.5 m were maintained between adjacent blocks and plots, respectively.

Table 1.Detail of treatment description

Treatment number	Wheat varieties	Row spacing(cm)	Treatment Combinations
1	King bird	15	King bird *15
2	King bird	25	King bird*25
3	King bird	35	King bird*35
4	Ogolcho	15	Ogolcho*15
5	Ogolcho	25	Ogolcho*25
6	Ogolcho	35	Ogolcho*35
7	Pavon	15	Pavon*15
8	Pavon	25	Pavon*25
9	Pavon	35	Pavon*35
10	Shorima	15	Shorima*15
11	Shorima	25	Shorima*25
12	Shorima	35	Shorima*35

Treatment 12 rep=3 total plot number 12*3=36

3.1.3. Procedures and field management

Total experimental plots were prepared for the experiment first by ploughing three times by oxen driven local plough in accordance with the local farming practices before sowing. Wheat seed lots having a physical purity of 97% and a germination of 85% were used. In accordance with the specifications of the design, afield layout was prepared and each treatment was assigned randomly to experimental plots within each block independently. Seeds of bread wheat were sown by hand at the end of July, 2021 with the recommended seed rate of 125 kg ha^{-1} All NPS fertilizers 100kg ha^{-1} were applied at planting time while N in the form of Urea 100kg ha^{-1} was applied in split doses 1/3 at planting and the remaining 2/3 top dressed 35 days after sowing and all agronomic practices were carried out according to recommendation for wheat. Plots were kept free of weeds by hand weeding. Fungicide (Senozole) at the rate of 0.5L hectare was applied since outbreak of rust diseases was occurred. Harvesting was done manually using hand sickle for each plot.

3.2. Data Collection on Wheat Crop Varieties

3.2.1 Meteorological Data

The rainfall and temperature data of the experimental site were collected during the cropping season from the nearby Sheshemene Kuyera Meteorological station.

3.2.2. Crop phenology

Days to 90% physiological maturity (DTM) was determined as the number of days from sowing to the date when 90% of the peduncle turned to yellow straw color. It was recorded when no green color remained on glumes and peduncles of the plants, *i.e.* when grains are difficult to break with thumb nail.

3.2.3. Data on growth, yield and yield components of bread wheat of varieties

Plant Height

The average height of five randomly selected plants from the net plot area of each plot was measured in centimeters from the ground to the top of spike, excluding awns at maturity and means were taken

Spike Length

The spike length was measured from ten randomly selected plants of the inner rows in centimeter and the mean length was recorded on each plot.

Number of Seeds per Spike

Number of seeds per spike was counted from ten randomly selected plants from the middle rows of each plot and the mean number was taken at harvesting.

Thousand seed weight

Thousand grains were counted after threshing picking randomly from each plot and their weight measured with sensitive balance.

Grain Yield

Grain yield was harvested from four central rows and recorded by measuring the weight of grains threshed from the net plot area (1.2 ^{m2}for 15cm,2^{m2}for 25cm and 2.8^{m2}for 35cm) of each plot and converted to kilograms per hectare after adjusting the grain moisture content to 12.5%.

Seed moisture content was adjusted to 12.5% after it was determined using the gravimetric method as per the following formula

Seed moisture conet (%) = Seed weight before oven dry- Seed weight after oven dry/Seed weight before oven dry

Total biomass harvested from the net area was weighed after sun drying for five days

Harvest index (%) $=\frac{\text{Grain yield}}{\text{Above ground dry biomass}} \times 100$

3.3. Statistical Analysis

The collected data were subjected to statistical analysis as per the experimental designs for the experiment using SAS software version nine (9). Mean separations of significant treatments were carried out using the least significant difference (LSD at 0.05) test.

4. RESULTS AND DISCUSSION

4.1 Soil phisico-chemical properties

Table 2. Major Soil phyisico-chemical properties of the experimental site

<table>
<tr><th>Parameters</th><th>Amount</th><th>Rating</th><th>References</th></tr>
<tr><td>Sand %</td><td>46</td><td rowspan="3">Loam</td><td rowspan="4">From west Arsi zone land use office , 2021 Year</td></tr>
<tr><td>Silt %</td><td>20</td></tr>
<tr><td>Clay %</td><td>34</td></tr>
<tr><td>pH</td><td>6.5</td><td></td></tr>
</table>

The soil class that are found in our specific study area are clay loam , sandy loam and sand clay loam. From those class of soil loam soil is limited in coverage and sand clay loam is huge in our specific study area according to the map (Fig. 2). The soil type that are found in our specific study area cambi soil ,luvi soil, lepto soil and Ando soil those are on the map. The suitability of the experimental soil in our specific study interms of texture are sandy clay loum and pH 6.5 for wheat production.

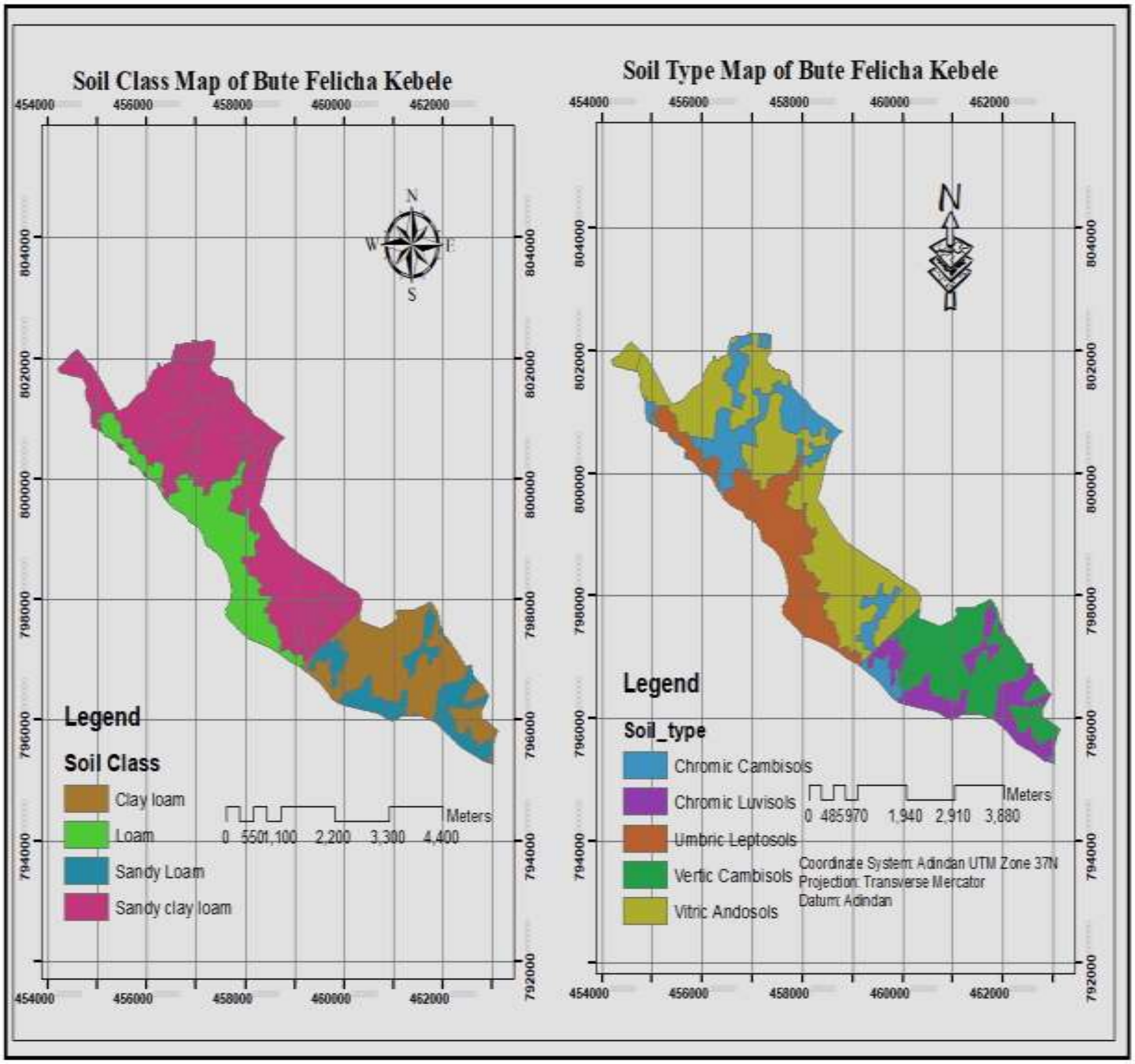

Fig 2 Soil Class and Soil Type Map

4.1.2 Grain yield and yield components

Grain yield: Data regarding grain yield is presented in Table 4. Analysis of the data indicated that row spacing and their interaction with varieties had no significant effect on grain yield while the effect of varieties was significant. The highest yield was obtained from variety shorima. (4405.55kg/ha) while the lowest from (3348.15 kg/ha) from variety King Bird. Similarly a study by Gawali et al. (2015) and Saeed et al. (2012) reported significant differences among the varieties of wheat for grain yield. The yield difference between the varieties could be due to their genetic difference.

Plant height: Statistical analysis of the data showed that varieties had a significant ($P < 0.05$) effect on plant height. While the effect of row spacing and their interaction with varieties was non-significant (Table 3). Analysis of the data indicated that the maximum plant height of 86.26 cm was attained by variety Ogolcho while the minimum plant height of 71.24 cm was obtained from King bird. The significant effect of variety on plant height might be due to different maturity group of varieties with early maturing variety King Bird having the shortest plant height.

Spike length: The result of this study showed that there were significant ($P<0.05$) differences found among four different varieties for spike length. The maximum (7.32 cm) spike length was observed by Ogolcho Variety and the minimum (6cm) spike length by King Bird. So, it can be indicated from these results that spike length is genetic character of a variety; which is less influenced by agronomic practices. As Khan *et al*. (2001) reported that varieties have different genetic potential regarding spike length.

Number of seeds per spike: Data recorded on number of seeds per spike is presented in Table 4. Statistical analysis of the data revealed that row spacing and variety had a significant ($P < 0.05$) effect on number of seeds per spike while their interaction had a non-significant effect. Maximum number of seeds per spike (55.6) was obtained from those plots where row spacing was kept at 15 cm and minimum number of seeds per spike (46.5) was obtained from plots where row spacing was 35 cm. The maximum number of seeds per spike (57) was obtained from variety Shorima while the minimum from variety Pavon 76 (41.29). The current results is in conformity with the findings of Bereket *et al*., (2014). Majid and Mohsen (2012) [35] who reported that significant differences were found among varieties in terms of the number of kernels spike. However, this was in contrast with Igorpirez *et al.* (2013) who reported that the wheat genotypes did not influence the number of grains per ear obtained in distinct seeding densities.

TSW: Data regarding 1000 grains weight is presented in Table 4. Analysis of the data revealed that row spacing and variety had significant ($p \leq 0.05$) effect on 1000 grain weight. The row spacing and variety interaction effect was also significant. The highest (40g) thousand seed weight of wheat was obtained from 15 row spacing. , while the lowest (35 g) from spacing 35 row.

Number of tiller: Statistical analysis of the data revealed that variety, row spacing and their interaction with varieties had a significant ($p \leq 0.05$) effect on umber of tiller. While the spacing non-significant (Table 3). Analysis of the data revealed that variety shorma(10) showed higher number of tillar compared to king bird ogolch and pavon This result agrees with the findings of Iqbal *et al* (2016) who reported that different number of productive tiller under different seeding rate.

Days to heading

Data concerning days to heading is presented in Table 3. Statistical analysis of the data indicated that row spacing and its interaction with variety had significant effect on days to heading while varieties had a significant effect ($P < 0.05$). Analysis of the data revealed that maximum days to heading was obtained from variety pavon, while the minimum from variety King bird. Tewodros *et al*., (2014) who reported that days to heading showed significant difference among wheat varieties.

Days to maturity

Statistical analysis of the data revealed that variety had a significant ($p \leq 0.05$) effect on days to maturity (Table 3). The effects of row spacing and the interaction of row spacing and variety were significant. Analysis of the data revealed that maximum days to maturity (115.2 days) were recorded for variety Pavon 76. In conformity with the present result Geng (1984) reported that, differences in maturity can be caused by the combined effect of genetic and environmental factors during their growth and grain filling of the crops.

Harvesting index

Data recorded on harvest index is shown in Table 3. Analysis of the data showed no significant effects of variety and their interaction with row spacing on Harvest Index. The effect of row spacing was significant ($P<0.05$). The maximum index value of harvest indexwas obtained from row spacing of 15 cm. . Similarly this result is supported by the findings of Tagesse et al. , (2018)

Table 3 Phenological and growth parameters of bread wheat

Row spacing (cm)	Til	DH	PH (CM)	TBM	HI	DM
15	8.58a	102.8a	81.80a	3.32a	0.54a	102.50a
25	8.50a	102.0c	79.83a	1.87b	0.50b	102.58a
35	8.41a	102.5b	76.55b	1.73a	0.40c	102.50a
LSD%	0.73	0.22	3.42	0.21	0.04	0.34
Variety						
Shorma	10.2a	55a	80.53b	4.39a	0.53a	104.88b
Pavon 76	8.3b	58a	79.50b	1.85a	0.48c	115.22a
Ogolcho	8.1b	53b	86.28a	1.69b	0.50a	100.00c
King bird	7.2c	50c	71.24c	1.29c	0.47d	90.00d
CV%	8.86	0.5	4.41	14.63	5.05	0.39
LSD%	0.73	0.22	3.42	0.21	0.04	0.34

Means with the same letters are not significantly different at 5% level of significantly, Til =tilering number PH= plant height, DH=Date of heading TBM=Total biomass HI= harvesting index DM= days to maturity in percent. LSD least significance difference and CV Coefficient of variation

Table 4. Yield and yield components of bread wheat

Row spacing (cm)	GY (Kg/ha)	SPL (cm)	NSPS	TSW (g)
15	5166.67a	7.60a	55.62a	35b
25	3809.72b	6.99a	47.91b	38 a
35	2956.94c	6.67a	46.53b	40 a
LSD%	541	0.58	2.13	0.26
Variety				
Shorima	4405a	6.85ab	57.03a	34.44b
Pavon 76	4353a	6.61b	41.92c	34.66bb
Ogolcho	3803ab	7.32a	55.12a	37.55a
King bird	3348.1b	6.08c	47.70b	32.11c
CV%	16.07	8.97	5.03	17.64
LSD%	541	0.58	2.13	0.26

Means with the same letters are not significantly different at 5% level of significantly,where indicate GY=grain yield, SPL= spike length, NSPS=Number of seeds per spike, TSW= Thousand seed weight in precent. LSD least significance difference and CV Coefficient of variation

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in Ethiopia. Among the cereal crops wheat contribute significantly to food security in the country. However, production and productivity of the crop is very low due to a number of factors. These factors include biotic (diseases, insects, and weeds), abiotic, and low adoption of new agricultural technologies. The experiment was conducted under rain-fed condition during the main cropping season from the end of July to – December, 2021at Shashemene District, West Arise Zone, of Oromia Regional state. The study was done using RCBD method and had been analyzed using SAS (statistical analysis software) with three replication and three levels of row spacing (15, 25 and 35cm) on wheat varieties of king bird, pavon, shorima and ogolicho consisting a total of 12 treatments. Analysis of variance showed that the main effect of row spacing had significant effect ($p < 0.05$) on grain yield and yield components.

5.2 Conclusion

Overall, taking all these above result into consideration we can conclude that different three levels of row spacing (15, 25 and 35cm) on wheat varieties gives different result. But the highest grain yield (5116.67 kg/ha), were obtained from Shorma varieties. Variety shorma had the maximum values in number of tillers(10.2), plant height (81.8 cm), total biomass weight (4.39g), grain yield (4405 kg/ha), spike length (7.32cm), number of seeds per spike (57.0kg), and thousand seed weight (37.5 gram). Among the spacing's 15 cm row spacing gave the highest yield.

5.3 Recommendation

The use of Variety Shorma on spacing's of 15cm can be recommended for production of bread wheat for the study area and other areas with similar agro ecologies. Based on research finding15cm spacing gives higher yield with variety shorma .Therefore the effect of row spacing on yield and yield component of bread wheat varieties need father research.

6. REFERENCE

Ahmed , J., M.I. Marwat and H.K. Ahmed. 2003.Effect of herbicides and row spacing on different traits of wheat (*Triticum aestivum* L.).*Pakistan J. Weed Sci.Res*.9 (1-2):33-40..

Annonymous. 2006. Pakistan Economic Survey 2005-06. Government of Pakistan, Finance Division, economic Advisor's wing Islamabad. Pp. 10-11.

Anonymous 2015. Wheat production in the world.

Ansari,M.A.,H.R.Meman,S.D.Tunio and S.A.Keerio.2006. Effect of planting pattern on growth and yieldofwheat.*PakistanJ.Agri.,Agril.Engg.,Vet.Sc.*22(2).

Anteneh A, Asrat D 2020 Wheat production and marketing in Ethiopia: review study. Cogent Food Agric 6:1778893.https://doi.org/10.1080/23311932.2020.1778893

Arif,M.,M.Ali,Q.M.Din,M.Akram and L.Ali.2003.Effect of different seed rates and row spacing on the growth and yield of wheat .*J.Anim.Pl.Sci*. 13(3):161-163.

Bekele Shiferaw, Menale Kassie, Moti Jaleta & Chilot Yirga. 2014. Adaption of improved wheat varieties and impact of house hold security in Ethiopia. *Food policy,* 44: 272-284.

Bergh, K., Chew, A., Gugerty, M. K., & Anderson, C. L. 2012. Wheat value chain: Ethiopia (Evince School Policy Analysis and Research, EPAR Brief number 104). Univerity of Washington.

Bezabih Woldekiros, 2020 ,International Journal of Research in Agriculture and Forestry

Braun H.J., Atlin G. & Payne T. 2010. Multi-location testing as a tool to identify plant response to global climate change. In: Reynolds, CRP. (ed.). Climate Change and Crop Production, CABI, London, UK.

Chaudhary,M.A.,A.Ali,M.A.Siddique and R.Sohail.2000.Growth and yield response of wheat to different seed rates and wild oat(*Avenafatua*) competition durations.*PakistanJ.Agri.Sci*.37(3-4):152-154.

CIMMYT (International Maize and Wheat Improvement Center). 2014. Wheat production and Use: Ethiopia. http://wheatatlas.org/country/production/ETH/0. Crops Res 228:20–30. https://doi.org/10.1016/j.fcr.2018.08.023

CSA (2019) Agriculture sample survey 2018/2019: volume I report on area and production of major crops. 589 Statistical Bulletin. Addis Ababa, Ethiopia. Technical report

CSA (Central Statistical Agency). 2016. Agricultural sample survey: area and production of major crops, meher season. Vol.I. Addis Ababa, Ethiopia .

CSA (Central Statistical Agency). Agricultural Sample Survey 2015/16 (2008 E.C) volume I: Technical Report on Area and Production for Major Crops. Statistical Bulletin No. 584. Addis Ababa, Ethiopia 2016.

CSA, 2017.The total areas of wheat production in the Oromia Region in 2017 were reported as 898,455.57 ha with average yields of 2.97 t ha^{-1} .

CSA, 2018.Agricultural Sample Survey Series, 2017/18: Report on Area and Production for Major Crops (Private Holdings, Main Season). Statistical Bulletin No.586. Central Statistics Agency of Ethiopia, Addis Ababa, Ethiopia. pp.15-30.

CSA. 2013. Agricultural sample survey report on area and production of major crops (Private peasant holdings, Meher season 2012/2013 (2005 E.C.)). The FDRE statistical bulletin, Volume 1.

CSA. 2014. Agricultural sample survey report on area and production of major crops. Statistical Bulletin Volume VI

CSA. Report on Area and Crop Production forecast for Major Crops (for private Peasant Holdings ’Meher’ season). Addis Ababa, Ethiopia. 2019.

Demeke, M., & Marcantonio, D. (2013). Analysis of incentives and disincentives for wheat in Ethiopia. Technical notes series. MAFAP, FAO.

Evenson and Gollin 2003, Grassini et al 2013Major time periods of this increase are associated with the ‘Green Revolution’, with the beginning generally dated to the 1960s, and the corresponding development of genetically improved wheat varieties .

FAO. 2014. Analysis of price incentives for wheat in Ethiopia. Technical notes series, MAFAP, by Wakeyo M.B., Lanos B.

FAOSTAT, 2012.Statistical databases and datasets of the Food and Agriculture Organization

Feldman M. 2001. Origin of cultivated wheat. P.3-56. In: Bonjean, A.P. and Angus, W.J., (ed.) The World Wheat Book: A History of Wheat Breeding. Lavoisier Publishing, Paris, France

Gashaw Tadesse, Alande Brauw, Nicholas Minot, and Tanguy Bernard. 2014. The Impact of the Use of New Technologies on Farmers Wheat Yield in Ethiopia: Evidence from a Randomized Controlled Trial. MoA.

Gebreselassie, S., Haile, M. G., & Kalkuhl, M. (2017). The wheat sector in Ethiopia: Current status and key challenges for future value chain development (ZEF Working Paper Series 160, Center for Development Research). University of Bonn.

Geleta,B.,M.Atak,P.S.Baenziger, L.A.Nelson, D.D. Baltenesperger ,K.M., Eskridge, M.J. Shipman and D.R. Shelton.2002.Seeding Rate and Genotype Effect on Agronomic Performance and end-use Quality.

Habte D, Tadesse K, Admasu W, Desalegn T, Mekonen A 2014 Agronomic and economic evaluation of the N and P response of bread wheat growin in the moist and humid mighighland

Hei, N., Shimelis, H. A., & Laing, M. 2017. Appraisal of farmers wheat production constraints and breeding priorities in rust prone agro-ecologies of Ethiopia. African Journal of Agricultural Research, 12(12), 944–952. https://doi.org/10.5897/AJAR2016.11518 Kiss, I. 2011. Significance of wheat production in world economy and position of hungary in it. Abstract: Applied studies in agribusiness and commerce [Thesis]. University of Debrecen.

Hochman Z, Horan H (2018) Causes of wheat yield gaps and opportunities to advance the water-limited yield frontier in Australia. Field

Hochman Z, Horan H 2018 Causes of wheat yield gaps and opportunities to advance the water-limited yield frontier in Australia. Field Crops Res 228:20–30. https://doi.org/10.1016/j.fcr.2018.08.023

https://books.google.com/books?isbn=0495556718): Accessed on May 05, 2018.

Iqbal N, Akbar N, Ali M, Sattar M, Ali L. Effect of seed rate and row spacing on yield and yield components of wheat (*Triticum aestivum* L.), J Agric. Res 2010;48(2):151-155.

Iqbal, N., N. Akbar, M. Ali, M. Sattar and L. Ali.2010. Effect of seed rate and row spacing on yield and yield components of wheat (*Triticum aestivium* L.).*Pakistan.J.Agric.Res*., 48(2)

Jennifer et al., 2006, Dense wheat population, grain yield was decreased due to competition between plants that induced self- regulation .

Khan, A.Z.,H.Khan,R.Khan,Adel Ghoneim and A. Ebid .2002.Effect of sowing dates and seed rates on yield and seed rates on yield and yield components of wheat. *Trendsin AppliedSci.Res*., 2(6):529-534.

Khan, M.A.,J. Anwar,A.Sattar and M.A.Akhtar.2001.Effect of seed rate on wheat yield under different sowing dates and row spacing. *J. Agric. Res*.39 (3-4):223-229.

Kumar A., Mishra V.K., Vyas R.P. & Singh V. 2011. Heterosis and combining ability analysis in bread wheat (*Triticum aestivum L*.). *Journal of Plant Breeding Crop Science*, 3: 209-217.

Mathewos, A.,Tewodros,M. and Yasin,G.,2012. Participatory on-farm evaluation of improved bread wheat technologies in some districts of southern Ethiopia. Journal of Biology, Agriculture and Healthcare , 2(4): 85-91.

Matouš, P., Todo, Y., & Mojo, D. (2013). Roles of extension and ethno-religious networks in acceptance of resource-conserving agriculture among Ethiopian farmers. International Journal of Agricultural Sustainability, 11(4), 301–316. https://doi.org/10. 1080/14735903.2012.751701

Minot N, Warner J, Lemma S, Kassa L, Gashaw A, Rashid S 2015. The Wheat Supply Chain in Ethiopia: Patterns, Trends, and Policy Options. International Food Policy Research Institute (IFPRI) Washington, DC.

Minot, N., Warner, J., Lemma, S., Kasa, L., Gashaw, A., & Rashid, S. 2015. The wheat supply chain in Ethiopia: Patterns, trends, and policy options. International Food Policy Research Institute (IFPRI).

Rafique SM, Rashid M, Akram MM, Ahmad J, Hussain R, Razzaq A. Optimum seed rate of wheat in available soil moisture under rainfed conditions. J Agric. Res 2010;47(2).

Rashid, S. 2010). Variation in staple food prices: Causes, consequence, and policy options., African Agricultural Marketing Project (AAMP).

Rattalino-Edreira JI, Mourtzinis S, Conley SP, Roth AC, Ciampitti IA, Licht MA, Kandel H, Kyveryga PM, Lindsey LE, Mueller DS, Naeve SL, Nafziger E, Specht JE, Stanley J, Staton MJ, Grassini P 2017 Assessing causes of yield gaps in agricultural areas with diversity in climate and soils. Agric Forest Meteorol 247:170–180.

Rattalino-Edreira JI, Mourtzinis S, Conley SP, Roth AC, Ciampitti IA, Licht MA, Kandel H, Kyveryga PM, Lindsey LE, Mueller DS, Naeve SL, Nafziger E, Specht JE, Stanley J, Staton MJ, Grassini P 2017 Assessing causes of yield gaps in agricultural areas with diversity in climate and soils. Agric Forest Meteorol 247:170–180.https://doi.org/10.1016/j.agrformet.2017.07.010

Ray et al 2012, 2013, Iizumi et al 2014 Grain yields of wheat considerably increased during the 20th century and more than half of the global wheat production areas still witness yield increases .

Sharma I.2012. Disease in Wheat Crops, introduction. *Disease Resistance in Wheat. CABI, oxfordshire*, Pp. 1-17.

Shewry P.R, 2007. Improving the protein content and composition of cereal grain. *Journal of Cereal Science*, 46: 239-250.

Shewry P.R. 2009. Wheat. *Journal of Experimental Botany*, 60(6): 1537-1553.

Silva JV, Baudron F, Reidsma P, Giller KE 2019a Is labour a major determinant of yield gaps in sub-Saharan Africa? A study for cereal-based production systems in Southern Ethiopia. Agric Syst 175:39–51. https://doi.org/10.1016/j.agsy.2019.04.009

Silva JV, Ramisch JJ 2019b Whose gap counts? The role of yield gap analysis within a development-oriented agronomy. Exper Agric 55:311–338. https://doi.org/10.1017/S0014479718000236

Singh, R.P., Hodson D.P., Yue Jin J.H., Peter N., Wanyera R., Herrera-Foessel S.A. & Ward R.W. 2008. Will stem rust destroy the world's wheat crop? *Journal of Advances in Agronomy*, 98: 271 – 309.

Staggenborg ,S.A., Whitney,D.A., D.L. Fjell and J.P. Shroyer. 2003. Seeding and nitrogen rates required .

Tadesse, W., Bishawand, Z., & Assefa, S. 2018. Wheat production and breeding in Sub-Saharan Africa challenges and opportunities in the face of climate change. International Journal of Climate Change Strategies and Management, 11(5), 696–715. https://doi.org/10.1108/IJCCSM-02-2018-0015

Umed Ali Soomro, Mujeeb Ur Rahman, Ejaz Ali Odhano, Shereen Gul, Abdul Qadir Tareen. Effects of Sowing Method and Seed Rate on Growth and Yield of Wheat (*Triticum aestivum*). World Journal of Agricultural Sciences 2009;5 (2):159-162.

USDA, 2019.World Agricultural Production and Agricultural projections. Oxford University Press. pp.32

van Ittersum MK, Cassman KG, Grassini P, Wolf J, Tittonell P, Hochman Z 2013a Yield gap analysis with local to global relevance - a review. Field Crops Res 143:4–17. https://doi.org/10.1016/j.fcr.2012.09.009

vertisols areas of Arsi zone, Ethiopia. Afr J Agric Res 10:89–99. Volume 7, PP 10-13

Warner J., Stehulak T., and Leulsegged K., 2015. Woreda-Level Crop Production Rankings in Ethiopia: A Pooled Data Approach. *International Food Policy Research Institute (IFPRI)*.Addis Ababa, Ethiopia.

Yordanos Ameyu. 2013. Influence of row spacing and nitrogen rates on yield and yield components of direct-sown irrigated rice at Gode, south-eastern Ethiopia. M.Sc thesis in Agronomy, Haramaya University, Haramaya

7.Appendix

SOV	DF	Yield(kg/ha)	PH(cm)	SPL(cm)	NSPS(#)	TGW(g)	TBM (%)	Til	DH
Spacing	**2**	2980^{**}	0.0061**	0.046ns	354.43***	15.47***	3.12^{***}	0.166^{ns}	1.0
Var	**3**	6759^{**}	1037.39^{**}	7.12^{**}	$1342.50*^{**}$	18.39***	2.48^{***}	42.777***	16
Rep	**2**	2980^{***}	159.44^{**}	0.04^{ns}	354.43***	15.47***	3.12^{***}	0.1666ns	1.0
Spacing* Var	**6**	2376^{ns}	123.06^{ns}	5.51*	3441.47***	26.91***	2.15***	23.388**	9.1
Error	**22**	8993 CV=16.07 LSD=541	269 CV=4.41 LSD=2.96	7.99 CV=8.97 LSD=0.51	139.47 CV=5.03 LSD=2.13	1.55 CV=17.64 LSD=0.22	1.45 CV=14.63 LSD=0.21	12.5 CV=8.86 LSD=0.63	1.6 CV LS

*: significant at P<0.05; **: significant difference at P<0.01; NS: non-significant at P<0.05; REP: replication;SR:seed rate;RS:row spacing;SOV: source of variation;df:degree of freedom;DH: days to heading;DM:days to maturity, plant height.

Seeds of bread wheat were sown by hand

Plots were kept free of weeds by hand weeding.

Urea was applied 2/3 top dressed 35 days after sowing

Plant height and spic length measured

Days to 90% physiological maturity (DTM)

SKETCH OF BIOGRAPHY

The author, Jemila Mengistu Dewano was born on June 6, 1985 GC at Dodola, West Arsi Zone, Oromia regional state, Ethiopia. At 1992 GC admitted grade 1 and completed her primary education (1-8) at Model and Dodola primary school. Then after, she attended her high school (9-10) and Kombolcha A.T.V.E.T Colleleg at Kombolcha . After completion of A.T.V.E.T Colleg, she worked at Dodola Agricultural Office .She joined Mada Wolabu University in 2012 to pursue her first Degree and graduated with BSc Degree in plant science on March 2015. After her graduation, she had worked at Dodola district agricultural office, until 2016 and 2018 she worked in West Arse Zone Agricultural Office. until she has got a chance to attend her Master's program. In 2019, She joined the Graduate program in Agronomy at Hawassa University. To pursue her MSc study.